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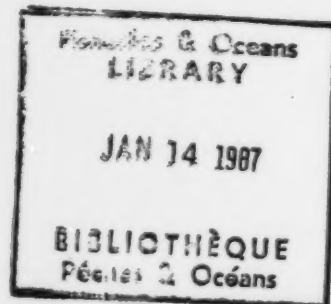
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IN LATE JULY

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SHIMAGATSUO (Brama japonica HILGENDORF) NO SEITAIGAKUTEKI KENKYU *

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II. AKANTAI KAIKI NI OKERU NANBOKU BUNPU NO ICHIREI

(ECOLOGICAL STUDIES ON THE POMFRET (Brama japonica HILGENDORF)

II. A NORTH-SOUTH DISTRIBUTION OF THE POMFRET ALONG LONGITUDE 175°30'E IN LATE JULY)

Seiji SASAKI **, Shoichi YAMAMOTO ** and Kenji SHIMAZAKI ***

Hokkaido Daigaku Suisangakubu Iho (Bulletin of the Faculty of Fisheries, Hokkaido University), 32(3), 225-233, 1981.

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Introduction

Since 1978 experimental fishing operations using surface gillnets have been carried out in the area 38° to 48°N along the longitude 175°30'E using the Training Ship "Hokusei Maru" of Hokkaido University. In these experimental fishing operations, many species of fishes including subtropical fishes have been caught^{1),2)} and valuable information has been obtained for the analyses of interrelationship between the subarctic ecology and the subtropic ecology.

* translator's note : actually, the text says : "drift net"; same throughout

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Pomfret, which indicate a large concentration of biomass during the experimental fishing operations, spawn in winter in the subtropic region and migrate northward to the subarctic region in summer which is regarded as being the feeding season^{3),4)}. However, their detailed group structure has not been clarified. In particular, due to the usage of gillnets, the following basic subjects remain to be studied; the values of biological measurements such as the composition of body length which is influenced by the selectivity of the mesh sizes and whether the relative abundance reflects the fishing ground conditions correctly.

During the summer of 1980, 20 mesh sizes of gillnet were used by the Hokusei Maru. Measurements were taken on all pomfret which were caught in the gillnet of 14 mesh sizes from 42 to 233 mm with common ratio 14 % used mainly for investigation of salmon⁵⁾. The selectivity of mesh sizes for pomfret was studied. It became clear that the gillnet used affected pomfret nonselectively⁶⁾. This result means that if the same number of tans^{*} of nets were used and all fish caught were measured, the composition of the fishing ground can be given most accurately. It also means that if the number of tans of nets used for each mesh size is known and if the number of fish caught and the measurements are accurate, the composition of the fishing ground can be obtained through appropriate correction.

Therefore it is thought that the samples obtained for

* translator's note : unit strip of netting

the measurements of pomfret caught at the time of investigation of the selectivity of the mesh size of nets reflect best the composition of body length and the relative abundance in the area investigated. Based on the material obtained, the authors analyzed a section of the north-south distribution in the subarctic region in summer. Results are reported below.

The authors would like to thank the officers and crew of the Training Ship "Hokusei Maru", Hokkaido University, for their cooperation in the collection of samples.

Samples and method

From the end of July to the beginning of August 1980, the Hokusei Maru carried out experimental fishing operations using gillnets made of 20 mesh sizes from 25 to 233 mm including those for the investigation of salmon. In this study, a series of gillnets made of 14 mesh sizes was used for the experiments⁵⁾ (hereinafter referred to as nonselective gillnets). These nets affected nonselectively toward pomfret with fork length 16-52 cm (hereinafter referred to as body length). Frequencies of body length in all mesh sizes at each experimental station were obtained. The number of tans used was 3 for each mesh size. This number was not changed during the period of the experiment. Since all pomfret caught were measured at each experimental station, it was not necessary to deal with the composition of body length by mesh size.

The number of experimental stations at latitude 38° to 48°N along longitude $175^{\circ}30'\text{E}$ was 7. The location of

Table 1. Date, location of experimental station and the number of pomfret caught by non-selective gillnet in late July 1980.

Exp. sta.	Position		Date	Catch No.
	Lat. (N)	Long (E)		
G. 1	38°43'	174°13'	July 26	18
2	39°58'	175°31'	27	10
3	41°31'	175°30'	28	626
4	43°01'	175°29'	29	363
5	44°32'	175°32'	30	223
6	46°06'	175°32'	31	85
7	47°31'	175°31'	Aug. 1	116

experimental stations and the number of pomfret caught are given in Table 1. The number of body length measured was 1441, the same as that of fish caught. The body weights of a portion of the total pomfret caught were also measured. Based on mean body length and body weight, the density of biomass at each experimental station was calculated from the number of pomfret caught. Then an area with a high density of biomass was estimated.

Results and discussion

1) Composition of body length

The composition of body length of pomfret differs according to the experimental station. However, three groups of body length were recognized (Fig. 1), namely, the body length of 16-30 cm (hereinafter referred to as small-sized fish), that of 35-46 cm (referred to as medium-sized fish) and that of 49-55 cm (referred to as large-sized fish). These groups of pomfret did not overlap in the range of body length and were clearly separated. The areas in which they appeared also differed according to latitude. The small-sized

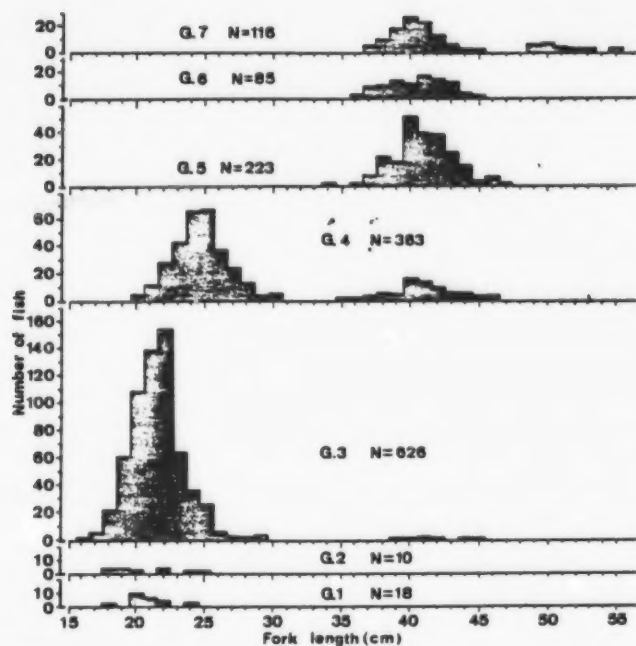


Fig. 1. Latitudinal changes of fork length caught by non-selective gillnet along longitude 175°30'E in late July 1980.

Table 2. Comparison of fork length of small pomfret between experimental stations.

Exp. sta.	G. 1 (n=18)	G. 2 (n=10)	G. 3 (n=619)	G. 4 (n=293)	Variance	(F-test)
G. 1		3.756 0.005 < p < 0.01	2.079 0.025 < p < 0.05	2.246 0.025 < p < 0.05	1.624	
G. 2	0.213 p > 0.50		1.798 0.10 > p > 0.05	1.672 0.25 > p > 0.10	6.100	
G. 3	2.140 0.025 < p < 0.05	0.818 0.50 > p > 0.40		1.071 0.50 > p > 0.25	3.405	
G. 4	11.818 p < 0.001	5.818 p < 0.001	23.609 p < 0.001		3.648	
Mean (cm)	20.72	20.90	21.38	24.51		(t-test)

pomfret appeared in the area G.1 to G.4 located on the south side of the experimental station. The number of appearances was smallest at G.1, the most southern side and at G.2 which

Table 3. Comparison of fork length of middle pomfret between experimental stations.

Exp. sta.	G. 3 (n=7)	G. 4 (n=70)	G. 5 (n=223)	G. 6 (n=85)	G. 7 (n=99)	Variance
G. 3		1.241 0.50 > p > 0.25	1.002 0.50 > p > 0.25	1.007 0.50 > p > 0.25	1.563 0.25 > p > 0.10	4.571
G. 4	0.670 p > 0.50		1.243 0.25 > p > 0.10	1.250 0.25 > p > 0.10	1.941 0.005 < p < 0.01	5.674
G. 5	0.887 0.50 > p > 0.25	0.329 p > 0.50		1.005 p > 0.50	1.561 0.01 < p < 0.025	4.563
G. 6	1.624 0.25 > p > 0.1	2.021 0.025 < p < 0.05	2.33 0.01 < p < 0.025		1.553 0.025 < p < 0.05	4.541
G. 7	2.091 0.025 < p < 0.05	2.385 0.01 < p < 0.025	3.099 p < 0.005	0.208 p > 0.50		2.924
Mean (cm)	41.71	41.09	40.99	40.35	40.29	

(F-test)

(t-test)

is adjacent to G.1 and greatest at G.3. The medium-sized pomfret appeared in the area north of G.3. They overlapped with the small-sized fish up to G.4. Many medium-sized fish were found in G.5 and also were mixed with the large-sized fish in G.7, the northernmost area. Characteristically, the small-sized fish were distributed in the southern area and the large-sized fish in the northern area.

In order to study the composition of body length of the group for each experimental station, the dispersion and mean values were compared. For the small-sized pomfret (Table 2), the dispersion in G.1 was significantly different from the other stations. The mean value in G.4 was significantly larger than the other 3 stations. A significant difference was observed between G.1-G.3 but not between G.1-G.2

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and G.2-G.3. The mean body length of the small-sized fish increases from the south to the north and is especially large in G.4.

For the medium-sized pomfret (Table 3), the dispersion in G.7 was significantly different from the other 3 stations except G.3, however, no significant difference was observed in the areas of the other experimental stations. The mean body length at each experimental station ranged from 40.3 to 41.7 cm. Significant differences were observed between G.3-G.7, G.4-G.5 and G.6-G.7. The variation in mean body length was not large but had a tendency of decreasing from the south to the north.

The mean body length for the large-sized pomfret in G.7 was 50.5 cm. The standard deviation was 1.62 (N=17). The mean body length of the large-sized fish was about 10 cm larger than that of the medium-sized fish and showed clearly a different composition.

2) Relationship between body length and body weight

In order to compare the relationship between body length and body weight in each group of body length among the experimental stations, a regression equation $\log W = \log w + a \log L$ (W: body weight g, L: body length cm, a and w are constant) was used. However, the small-sized fish in G.2 and the medium-sized fish in G.4 were excluded as they had a lesser number of body weight measurements.

There was no significant difference in the coefficient

Table 4. Comparison of the increasing coefficient and the adjusted mean in the weight-length relationship of small pomfret between experimental stations.

Exp. sta.	G. 1	G. 3	G. 4	Adjusted mean
G. 1		1.872 df: 1, 32 0.25 > p > 0.10	2.219 df: 1, 37 0.25 > p > 0.10	
G. 3	0.757 df: 1, 31 0.50 > p > 0.25		0.312 df: 1, 36 p > 0.5	
G. 4	0.035 df: 1, 36 p > 0.50	1.566 df: 1, 35 0.25 > p > 0.10		
Coefficient				

Table 5. Comparison of the increasing coefficient and the adjusted mean in the weight-length relationship of middle pomfret between experimental stations.

Exp. sta.	G. 5	G. 6	G. 7	Adjusted mean
G. 5		2.778 df: 1, 54 0.25 > p > 0.10	1.887 df: 1, 50 0.25 > p > 0.10	
G. 6	0.208 df: 1, 53 p > 0.50		0.040 df: 1, 49 p > 0.5	
G. 7	0.434 df: 1, 49 p > 0.50	0.064 df: 1, 48 p > 0.50		
Coefficient				

Table 6. Comparison of the increasing coefficient and the adjusted mean in the weight-length relationship between small and middle pomfret.

Size	F-test for slope			F-test for adjusted mean		
	df	F ₀	p	df	F ₀	p
Middle						
Small	1, 134	0.440	> 0.50	1, 135	0.833	0.50 > p > 0.25

of increase a and the adjusted mean values among the experimental stations for the small-sized fish (Table 4) and the medium-sized fish (Table 5). Therefore the groups of body length were treated collectively. The coefficient of increase and the adjusted mean values for the small-sized fish and the

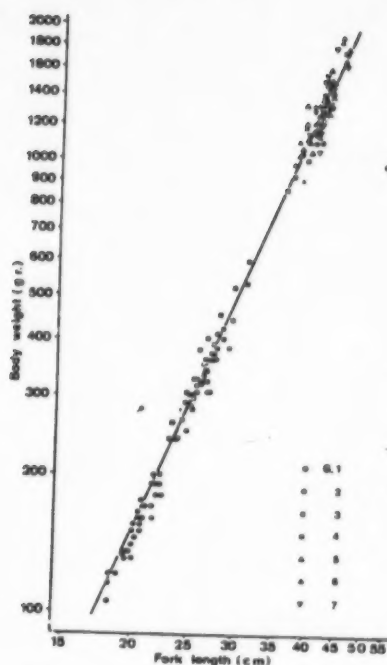


Fig. 2. Relationship between fork length and body weight.

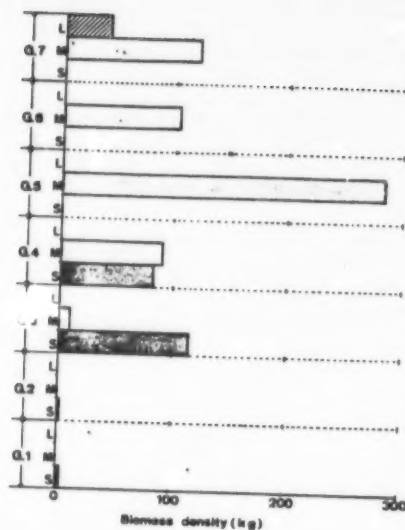


Fig. 3. Latitudinal changes of biomass density caught by non-selective gillnet along longitude 175°30'E in late July 1980.
S: Small pomfret. M: Middle pomfret. L: Large pomfret.

medium-sized fish in all the experimental stations were compared. However, no significant difference was observed (Table 6). Consequently a regression line for the measured values of all the experimental stations was obtained with the following values: $a=2.96$, $\log w=-1.67$ (Fig. 2).

As seen from the results above, the mode of distribution of pomfret showed that the small-sized fish were distributed near the subarctic ocean front and the body length increased toward the north. It became clear that in each distribution range, the small-sized fish became larger in the north but the medium-sized fish became somewhat smaller in

the north. The large-sized fish were distributed in the northernmost area.

This characteristic of north-south distribution is p. 230 already recognized at the edge of the subarctic ocean front in spring when pomfret start to migrate northward from the subtropic region to the subarctic region⁷⁾. It has been thought that the distribution area for pomfret expands to the north of the subarctic region from spring to summer. In autumn, the medium-sized fish and the large-sized fish migrate northward to the Kurile current which is the northernmost area in the distribution whereas the small-sized fish are distributed continuously south of this area⁴⁾. From the distribution characteristics of the body length obtained from this experiment, almost the same distribution pattern is maintained in the subarctic region.

In the north-south distribution, the number of fish was largest in G.3 which was the main group for the small-sized fish. The number decreased in the southern area and the northern area in which the medium-sized fish were the prominent group. The subarctic region is the feeding ground for this species in summer and the body weight increases greatly⁴⁾. From the point of view of energy transfer, it is necessary to examine the distribution in relation to biomass density.

Body weight measurements were taken only for a portion of the catch at each experimental station. The regression

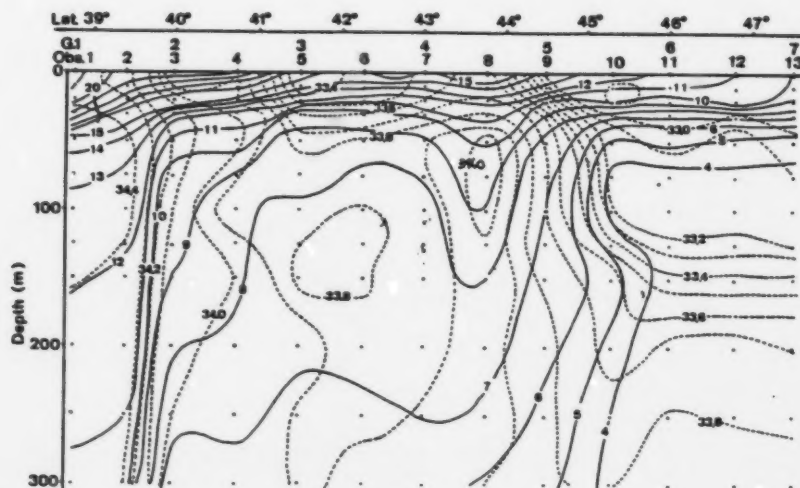


Fig. 4. Vertical section of temperature and salinity along longitude 175°30'E in late July 1980.

lines of body length and body weight did not differ by body length group or among the experimental stations. The body weight for the mean body length of each body length group at each experimental station (Tables 2 and 3) was calculated. The values thus obtained show the mean body weight. The weight was obtained from these values and the number of fish ^{from} by the body length group at each experimental station. If this amount is regarded as weight per unit, the weight obtained can be expressed as biomass density. The result is given in Fig. 3.

From this figure, the experimental station with the highest biomass density was G.5 followed by G.4. G.7, the northernmost station, was also high. At G.3 which showed the highest abundance, the biomass density was not high because the small-sized fish were the main group. G.1 and G.2 which

which were on the south side showed a very low biomass density. The body length group of medium-sized fish at this longitude in the autumn is mainly distributed in the Kurile current. It decreases in the transitional zone to the south. It decreases further in the subtropical region which is further south⁴⁾. In order p. 231 to compare this distribution characteristic and the results of this experiment, a vertical north-south section of water temperature and salinity was obtained from oceanographic observations which were conducted at the same time. The result is given in Fig. 4. From this figure, the subarctic ocean front which is indicated by the salinity 34 ‰ is at about 40°N. The Kurile current zone with medium cold water below 4°C is seen north of 45°N⁸⁾. The area from 41° to 45°N is estimated to be a transitional zone.

The water temperature of the northern limit of the pomfret distribution is considered to be 9°-10°C^{9),10)}. G.7 is located at the northern limit of the distribution. When observed vertically, the water temperature zone over 9°-10°C exists in the area shallower than 30-50 m in the north of the subarctic ocean front. It seems that pomfret are distributed in this water temperature zone. G.5 which has the highest biomass density is located at the northern edge of the transitional zone, however, it does not reach the Kurile current where the density increases in autumn. The large-sized fish and a portion of the medium-sized fish expand the distribution zone to the Kurile current and the centre of the distribution

moves further to the north until autumn.

The small-sized fish are mainly distributed in the transitional zone which is south of G.4. The number is very low in the subarctic ocean front and in G.1 and G.2 which are south of the subarctic ocean front. The vertical stratification of water temperature in this area is not as definite as that in the subarctic region. The range where the distribution of the small-sized fish is possible is vertically deep. Therefore we cannot deny the possibility that this reflects the low catch by surface gillnets. However, the abundance of small-sized fish is very high in G.3 and G.4. Therefore this area can be regarded as the centre of the distribution where a part of it overlaps the southern edge of the medium-sized fish area.

The northward migration of pomfret begins in spring when the surface layer of the subarctic region becomes warm. The northern limit of the distribution moves northward with time and it reaches the north of the North Pacific Ocean by September^{4),9),10),11)}. The end of July when this experiment was conducted corresponds to the time of northward migration and the large-sized fish were in the lead. Since no method of determining the age of pomfret is established, the characteristics of the distribution by body length cannot be dealt with as age groups. However, since the modes of body length clearly differ and their extremes do not overlap, each can be regarded as a group with a different life history.

It is estimated that pomfret spawn in the subtropical region in winter^{4),12)}. However, the spawning season can extend to early summer according to the region¹²⁾. When the spawning season lasts long, groups with different body lengths may exist even for the small-sized fish. Therefore the small-sized fish with a large mean body length which appeared in G.4 can be considered to be a group of the same year which developed earlier than the small-sized fish to the south. p. 232

It is necessary to establish without delay a method of determining age for the analyses of the structure of these fish groups and their growth.

It is not clear what adjustment influenced the distribution characteristics of the composition of body length of this species in the subarctic region stated above. The degree of fatness obtained from the relationship between the body length and the body weight had almost the same values in the north and the south of the subarctic region. The degree of fatness of the large-sized fish in the lead was not especially high and had the mean value of the seasonal variation⁴⁾. This value is expected to increase by autumn. In order to analyze the distribution characteristics of this species in the feeding season, it is necessary to study further the distribution characteristics of feed organisms according to the region, the difference in food habit in different growth stages and the struggle for existence between individuals of the same species and between different species.

This species is mixed with salmon, a typical epipelagic fish of the subarctic region and especially with a portion of fish-eating coho salmon (Onchorhynchus kisutch) in the northern limit of the distribution. On the south side, the fishes which have migrated northward from the subtropical region are distributed continuously^{1),2),4)}. This species is distributed widely in the subtropical region^{4),13)} and migrates northward in concentration to the subarctic region, the feeding zone. Therefore it can be assumed that this species is strongly involved in the energy transfer of both regions. It is necessary to clarify the ecological significance of these many species of fish which migrate from south to north at the same time. In order to study the group structure, the biomass density and the ecological position, we should accumulate many careful observations with impartial methods and with the proper use of fishing gear.

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Abstract

For the purpose of clarifying the distribution of pomfret in the North Pacific Ocean in summer, experimental fishing operations were carried out to obtain samples along the longitude 175°30'E in late July.

This paper contains the results of the 1980 experimental fishing operations using non-selective gillnet for pomfret. In this experimental fishing, it was a rule that the same number of tans of nets should be used for each mesh size, and that all fish caught should be biologically measured.

The summer distribution of feeding group was restricted mainly to waters north of the Subarctic Boundary.

Fork length frequency indicates the presence of three modes (mean fork length 22, 41, and 51 cm). The mean fork length generally increased in the Subarctic Current rather than in the warm waters. The small fish were distributed throughout the southern part of the Transitional Zone, and the middle fish were north of the small fish but somewhat south of the large fish.

The mean concentrations of abundance were near concentrations of the small pomfret. The greatest concentration of the biomass density were near mean concentrations of the middle pomfret. This latitude is intermediate between known latitudes of concentrations in summer and winter, and this suggests that feeding group were moving north at this time.